

CLAIMS:

What is claimed is:

1. A method for improving fluidic flow for a microfluidic device having a through hole or slot therein, the method comprising the steps of:
forming one or more openings through at least part of a thickness of a substrate from a first surface to an opposite second surface using a reactive ion etching process whereby an etch stop layer is applied to side wall surfaces in the one or more openings during alternating etching and passivating steps as the openings are etched through at least part of the thickness of the substrate; and
removing substantially all of the etch stop layer coating from the side wall surfaces by treating the side wall surfaces using a method selected from chemical treatment and mechanical treatment, whereby a surface energy of the treated side wall surfaces is increased relative to a surface energy of the side wall surfaces containing the etch stop layer coating.
2. The method of claim 1 wherein the reactive ion etching process comprises deep reactive ion etching using an etch stop layer derived from a fluorinated C₂ to C₄ compound.
3. The method of claim 1 wherein the treating method comprises a mechanical treatment selected from the group consisting of a puff grit blast treatment and a water blast treatment.
4. The method of claim 1 wherein the treating method comprises a treatment selected from the group consisting of plasma or ozone treatments in a treatment chamber, exposing the openings to a focused ion beam, exposing the openings to a laser beam, and ultrasonically cleaning the openings.
5. The method of claim 1 wherein treating method comprises chemical treatment and the chemical treatment includes contacting the side wall surfaces of the

substrate with a perfluorinated compound for a first period of time sufficient to remove sufficient etch stop layer coating on the side wall surfaces to provide a water
5 contact angle of less than about ninety degrees.

6. The method of claim 5 further comprising rinsing the side wall surfaces of the substrate with a solvent selected from the group consisting of C₁ to C₄ alcohol, acetone, glycol ether, and ethers to remove substantially all of the perfluorinated compound from the side wall surfaces.

7. The method of claim 6 further comprising heat treating the solvent rinsed substrate at an elevated temperature above room temperature.

8. The method of claim 5 further comprising heat treating the chemically treated substrate at an elevated temperature above room temperature.

9. The method of claim 5 wherein the perfluorinated compound comprises a compound selected from the group consisting of perfluorinated alkanes, perfluorinated cycloalkanes, perfluorinated aromatics, and perfluoropolyethers.

10. The method of claim 1 wherein the treating method comprises chemical treatment and the chemical treatment includes contacting the side wall surfaces of the substrate with a fluorinated compound for a first period of time sufficient to remove sufficient etch stop layer coating on the side wall surfaces to
5 provide a water contact angle of less than about ninety degrees.

11. The method of claim 10 further comprising rinsing the side wall surfaces of the substrate with a solvent selected from the group consisting of C₁ to C₄ alcohol, acetone, glycol ether, and ethers to remove substantially all of the fluorinated compound from the side wall surfaces.

12. The method of claim 11 further comprising heat treating the solvent rinsed substrate at an elevated temperature above room temperature for from about 10 to about 15 minutes.

13. The method of claim 10 further comprising heat treating the chemically treated substrate at an elevated temperature above room temperature for a second period of time.

14. The method of claim 10 wherein the fluorinated compound comprises a compound selected from the group consisting of fluorinated alkanes, fluorinated cycloalkanes, fluorinated aromatics, and fluoroethers.

15. An ink jet printhead chip made by the method of claim 1.

16. A method for making a micro-fluid ejecting device comprising the steps of:

providing a semiconductor substrate having a thickness ranging from about 400 to about 900 microns and having a first surface and a second surface
5 opposite the first surface;

micromachining one or more fluid flow openings through the semiconductor substrate for fluid flow communication from the second surface to the first surface of the substrate, the one or more fluid flow openings including side wall surfaces having a first water contact angle greater than ninety degrees;

10 treating the one or more fluid flow openings to provide one or more fluid flow openings having a second water contact angle less than ninety degrees; and

attaching a nozzle plate to the semiconductor substrate to provide the micro-fluid ejecting device.

17. The method of claim 16 wherein the treating step comprises treating the fluid flow openings with a method selected from chemical treatment and mechanical treatment.

18. The method of claim 17 wherein the treating step comprises mechanical treatment selected from the group consisting of a puff grit blast treatment and a water blast treatment.

19. The method of claim 17 wherein the treating step comprises a treatment selected from the group consisting of plasma or ozone treatments in a treatment chamber, exposing the openings to a focused ion beam, exposing the openings to a laser beam, and ultrasonically cleaning the openings.

20. The method of claim 17 wherein the treating step comprises chemical treatment and the chemical treatment includes contacting at least side wall surfaces of the one or more fluid flow openings with a fluorinated or perfluorinated compound for a first period of time.

21. The method of claim 20 wherein the perfluorinated compound comprises a compound selected from the group consisting of fluorinated alkanes, fluorinated cycloalkanes, fluorinated aromatics, fluoroethers, perfluorinated alkanes, perfluorinated cycloalkanes, perfluorinated aromatics, and perfluoropolyethers.

22. The method of claim 20 further comprising rinsing the fluid flow openings with a solvent selected from the group consisting of C₁ to C₄ alcohol, acetone, glycol ether, and ethers to remove substantially all of the perfluorinated or fluorinated compound from the side wall surfaces of the fluid flow openings.

23. The method of claim 22 further comprising heat treating the semiconductor substrate for a second period of time at an elevated temperature above room temperature.

24. The method of claim 20 further comprising heat treating the semiconductor substrate for a second period of time at an elevated temperature above room temperature.

25. A silicon semiconductor substrate for an ink jet printhead, the substrate comprising a first surface, a second surface opposite the first surface, and one or more ink feed ports therein extending from the first surface to the second surface, the one or more ink feed ports are formed at least in part by a reactive ion
5 etching process and having side wall surfaces having a water contact angle of less than about ninety degrees for improved ink flow through the one or more ink feed ports.

26. The silicon semiconductor substrate of claim 25 wherein the ink feed ports formed by a reactive ion etching process have side wall surfaces having an initial water contact angle of greater than about ninety degrees prior to treating the ink feed ports by a chemical or mechanical treatment method and have side wall surfaces
5 having a water contact angle of at less than about ninety degrees after treating the ink feed ports with a chemical or mechanical treatment method.

27. The silicon semiconductor substrate of claim 26 wherein the initial water contact angle of the side wall surfaces of the ink feed ports is provided by a passivating layer coating derived from a fluorinated C₂ to C₄ compound.

28. The silicon semiconductor substrate of claim 27 wherein the water contact angle of less than about ninety degrees is provided by side wall surfaces of the ink feed ports that are substantially devoid of the passivating layer coating.

29. The silicon semiconductor substrate of claim 25 wherein the water contact angle of less than about ninety degrees is provided by the side wall surfaces of the ink feed ports substantially devoid of a passivating layer coating formed on the side wall surfaces during the reactive ion etching process for forming the ink feed
5 ports.